Chapter 7: Shapes and Patterns

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Exercise 7.1 — Weaving Mats — Paper Mat Activities (p. 92–93)

Q1 Let us make paper mats. Follow the steps: (a) Take a coloured paper 30 cm long and 20 cm wide. (b) Fold it in half along the longer side. (c) Draw vertical lines at equal distances from the closed end and cut slits, leaving a gap of 3 cm at the top. (d) Carefully unfold the paper. (e) Cut 8 paper strips of 3 cm width in 2 colours, slightly longer than 20 cm. (f) Weave the first strip going 1 under, 1 over, 1 under, 1 over. (g) Weave the second strip going 1 over, 1 under, 1 over, 1 under. (h) Weave all strips in the same alternating pattern.

SOLUTION

This is a hands-on activity. Follow each step carefully.

The weaving pattern for this mat is:
Row 1 — 1 under, 1 over, 1 under, 1 over, ... (repeat)
Row 2 — 1 over, 1 under, 1 over, 1 under, ... (repeat)

Each row is the opposite of the row above it. This alternating pattern holds the strips in place firmly and creates an even, checkerboard-like surface.

Answer: Follow the steps to weave the mat. The pattern alternates: Row 1 is 1 under–1 over (repeat); Row 2 is 1 over–1 under (repeat). Each row is the reverse of the row above.

Q2 Can you figure out how to make this mat? The weaving pattern for the first two rows is: Row 1 — 2 over, 1 under, 2 over, 1 under, ... Row 2 — 2 under, 1 over, 2 under, 1 over, ...

SOLUTION

This mat uses a 2-over, 1-under pattern instead of the simple 1-over, 1-under pattern.

To make it, weave each row following the rule:
Row 1 — Go 2 over, then 1 under, and repeat across the row.
Row 2 — Go 2 under, then 1 over, and repeat across the row.

You can use strips of the same colour or two different colours (one colour per row) to make the pattern easier to see.

Answer: Weave Row 1 as: 2 over, 1 under (repeat). Weave Row 2 as: 2 under, 1 over (repeat). Alternate these two rows. Use two colours (one per row) to see the pattern clearly.

Q3 Try to weave a pattern using the rules given below.
Row 1 — 2 over, 1 under, 2 over, 1 under, ... (repeat)
Row 2 — 1 under (do not repeat), 3 over, 3 under, 3 over, 3 under, ... (repeat)
Row 3 — 2 under, 1 over, 2 under, ... (repeat)
Row 4 — 1 over (do not repeat), 3 under, 3 over, ... (repeat)
Continue weaving in this order.

SOLUTION

This is a hands-on weaving activity. The 4-row pattern creates a diagonal brick-like design.

Key things to notice:
— Rows 1 and 3 are mirror images of each other (2-over-1-under vs 2-under-1-over).
— Rows 2 and 4 start with a single stitch that does NOT repeat; the 3-over-3-under part then repeats.
— After Row 4, go back to Row 1 and keep repeating the 4-row cycle.

Use 2 contrasting colours for the strips to see the diagonal pattern clearly.

Answer: Follow the 4-row cycle as given. Rows 1 and 3 are 2-and-1 patterns; Rows 2 and 4 start with a single stitch and then use a 3-and-3 repeating pattern. Repeat the cycle to build the full mat.

Q4 Can you work out the steps for any of these designs and weave the pattern? Write the steps of the pattern in your notebook for each row until it starts repeating. (Two woven mat designs with diagonal brick-like patterns are shown.)

SOLUTION

This is an open observation and hands-on activity. Look at the design carefully and identify how many rows make up one repeating cycle.

Model answer for a typical diagonal brick design:

Row 1 — 1 over, 2 under, 1 over, 2 under, ... (repeat)
Row 2 — 1 under, 1 over, 2 under, 1 over, 2 under, ... (repeat, shifted by 1)
Row 3 — same as Row 1.

Steps to find the rule: weave one row slowly, write down each 'over' or 'under' for the first 6 strips. Look for the shortest repeating unit. Check if the next row is a shift or a mirror of Row 1.

Answer: Observe each design, weave one row and write 'over'/'under' for each strip. Find the shortest repeating unit. Check how the next row differs (shifted or mirrored). Repeat the cycle to complete the mat.

Exercise 7.2 — Let Us Try — Grid Pattern Drawing (p. 93)

Q1 Draw the following pattern on a grid paper. Part of it is done for you. Complete the rest of the grid to get the full design. (A woven mat pattern is shown partially filled in a dotted grid.)

SOLUTION

This is a drawing activity on grid paper.

How to complete the design:

1. Look at the part already drawn — notice which grid squares are filled and which are empty.
2. Identify the repeating unit (a small block of filled and empty squares that tiles to make the full pattern).
3. Extend the same block across and down the rest of the grid, colouring each square to match.

The pattern in the figure alternates filled and unfilled squares in a regular repeating design, similar to a weave.

Answer: Find the repeating block in the sample, then copy it across the entire grid. Each row should follow the same filled/empty pattern, offset appropriately to create the full weave design.

Exercise 7.3 — Tiling and Tessellation / Find Out — Regular Shapes (p. 94–95)

Q1 Can regular triangles (equilateral triangles) fit together at a point without any gap? How many of them fit together? (Use the sample triangle from the end of the book.)

SOLUTION

Yes, regular (equilateral) triangles fit perfectly around a point without any gap or overlap.
6 equilateral triangles fit around a single point.

Why? Each angle of an equilateral triangle is 60 degrees.
6 x 60 = 360 degrees, which is exactly one full turn around a point.
So 6 triangles fit perfectly.

Answer: Yes. 6 equilateral triangles fit around a point with no gap. Each angle is 60 degrees, and 6 x 60 = 360 degrees (a full circle).

Q2 Can squares (regular 4-sided shapes) fit together around a point without any gap or overlap? How many squares fit together at a point? Can five squares fit together at a point without gaps or overlaps? Why or why not?

SOLUTION

Yes, squares fit perfectly around a point. 4 squares fit together at a point with no gap.

Why? Each angle of a square is 90 degrees.
4 x 90 = 360 degrees, which is a full turn.
So exactly 4 squares meet at a point with no gap and no overlap.

Can 5 squares fit? No.
5 x 90 = 450 degrees, which is more than 360 degrees.
Five squares would overlap each other, so they cannot all fit around one point.

Answer: Yes — 4 squares fit around a point (4 x 90 = 360 degrees). Five squares cannot fit because 5 x 90 = 450 degrees, which is more than 360 degrees — they would overlap.

Q3 Can regular hexagons (6-sided shapes with equal sides) fit together around a point without any gaps or overlaps? How many fit together at a point?

SOLUTION

Yes, regular hexagons fit perfectly around a point. 3 hexagons fit together at a point.

Why? Each interior angle of a regular hexagon is 120 degrees.
3 x 120 = 360 degrees, which is a full turn.
So exactly 3 regular hexagons meet at a point with no gap and no overlap.

Answer: Yes — 3 regular hexagons fit around a point (3 x 120 = 360 degrees). Regular hexagons tessellate.

Q4 Here is a tessellating pattern with more than one shape. What shapes have been used in this pattern? (A pattern using two shapes — large hexagon-like shapes and triangles — is shown.)

SOLUTION

Looking at the figure, two shapes are used:

1. Hexagons (6-sided shapes)
2. Triangles

The triangles fill the gaps between the hexagons, allowing the pattern to cover the surface without any gaps or overlaps.

Answer: The two shapes used are hexagons and triangles.

Q5 Continue the pattern given below and colour it appropriately. (A partly drawn pattern of hexagons and triangles is shown on a dotted grid.)

SOLUTION

This is a drawing and colouring activity.

The pattern shown uses hexagons with triangles filling the gaps between them (the triangles form six-pointed stars around each hexagon).

To continue:

1. Extend the row of hexagons to the right and below, keeping equal spacing.
2. Fill each gap between the hexagons with triangles.
3. Colour all hexagons one colour and all triangles another colour.

Answer: Continue the pattern by extending the hexagons in rows and columns. Fill the gaps between the hexagons with triangles. Colour hexagons and triangles in two different colours.

Q6 Look at the pattern given below. What shapes are coming together at the marked points? Are the same set of shapes coming together at these points? Continue the pattern and colour it appropriately. (A pattern of regular octagons and small squares on a dotted grid is shown, with two points marked.)

SOLUTION

From the figure, the pattern uses regular octagons and small squares.

At the marked points, the shapes that come together are:
2 octagons and 1 square meet at each marked point.

Yes, the same set of shapes (2 octagons + 1 square) comes together at each of the marked points.
(Each octagon angle is 135 degrees and the square angle is 90 degrees: 135 + 135 + 90 = 360 degrees, a full turn.)

To continue the pattern, extend the octagons in rows and columns and fill corner gaps with squares, then colour appropriately.

Answer: At each marked point: 2 octagons and 1 square come together (135 + 135 + 90 = 360 degrees). Yes, the same combination appears at all marked points. Continue the pattern by repeating the octagon-with-square-gaps tile.

Q7 Here is a tiling pattern made using two different shapes — squares and triangles. Are the triangles equilateral? Why or why not? What shapes are coming together at the marked points? Are the same set of shapes coming together at these points? Continue the pattern and colour it appropriately.

SOLUTION

Are the triangles equilateral? No, they are not equilateral.

The triangles sit between the squares, and their base is the same length as the side of the square, but their two equal sides are longer (they lean diagonally). So the three sides are not all equal, which means they are not equilateral triangles. They are isosceles triangles.

At the marked points, squares and triangles come together. The same set of shapes (squares and triangles) meets at each marked point, so the pattern repeats evenly.

To continue: extend the squares and add triangles in the gaps between them, then colour squares and triangles in two different colours.

Answer: No — the triangles are not equilateral. Their base equals the square's side but the other sides are longer (they are isosceles). At the marked points, squares and triangles come together, and the same combination appears at each point. Continue the pattern by extending squares and filling the triangle gaps.

Exercise 7.4 — Rhombus Triangle Activities — Triangles and Quadrilaterals (p. 96–98)

Q1 What geometrical shapes can you make by fitting 2 triangles (from the rhombus cutout) together? Trace the shapes you created. How many different types of triangles can you make? Observe and measure the sides of these triangles. What do you notice?

SOLUTION

Each piece cut from the rhombus is a triangle with two equal sides (an isosceles triangle).
Fit the two identical pieces together along different matching edges and trace what you get:
- Joined along the equal (slant) sides, the outer edges line up to form a larger triangle.
- Joined along the cut (diagonal) edge, you get back the rhombus (not a triangle).

By trying the different edges you can make more than one triangle. Measure the sides each time: the triangles you form are isosceles (two equal sides), so they also have two equal angles.

Answer: Fitting the two equal pieces along different edges makes more than one triangle (for example a larger isosceles triangle); joining along the cut edge gives back the rhombus. The triangles formed are isosceles - two equal sides and two equal angles. (Trace and measure to compare.)

Q2 Is it possible to make a triangle where all three sides are equal (equilateral triangle) using the rhombus triangles?

SOLUTION

No, you cannot make an equilateral triangle directly by fitting the isosceles triangles from the rhombus together.
The pieces from the rhombus are isosceles (2 sides equal), and when joined they do not naturally produce a triangle with all three sides equal.

However, if you use the separate equilateral triangle cutout provided at the end of the book, you can explore equilateral triangles separately.

Answer: No — the rhombus pieces are isosceles triangles, so fitting them together does not give a triangle with all three sides equal.

Q3 Is it possible to make a triangle where all three sides are unequal (scalene triangle) using the rhombus triangles?

SOLUTION

Yes, it is possible to make a scalene triangle using the rhombus pieces.
When you cut an equilateral triangle in half, each half is a scalene triangle — a triangle with no two sides equal.

Scalene triangles have no two sides equal, and no two angles are equal either.

Answer: Yes — cutting an equilateral triangle in half gives a scalene triangle (no two sides equal, no two angles equal).

Q4 How many different 4-sided shapes (quadrilaterals) can you make using 2 triangles from the rhombus? What do you notice about the shape called a kite? (Side 1 = Side 2, Side 3 = Side 4 — these are adjacent sides.)

SOLUTION

Using 2 rhombus triangles you can make several different quadrilaterals by joining them along different edges.
Three possible shapes shown in the book are:
1. A parallelogram (joining two triangles base to base)
2. A kite (joining two triangles along a different edge)
3. Another irregular quadrilateral

About the kite:
A kite has two pairs of adjacent (next to each other) sides that are equal.
In the kite: Side 1 = Side 2 and Side 3 = Side 4.
These equal sides are adjacent (they share a corner), not opposite.

Answer: You can make at least 3 different quadrilaterals: a parallelogram, a kite, and another shape. In a kite, two pairs of adjacent sides are equal: Side 1 = Side 2 and Side 3 = Side 4.

Q5 Measure the sides of each of the two quadrilaterals A and B (shown in the book). What do you notice? Are there any pairs of sides that are equal? Which pairs are equal — adjacent or opposite? What types of angles do A and B have? Which angles are equal in each?

SOLUTION

From measuring the figures:

Quadrilateral A (slanted parallelogram):
— Opposite sides are equal (top = bottom, left = right).
— The sides do NOT make right angles — the angles are slanted.
— Opposite angles are equal (the two sharp angles are equal; the two wide angles are equal).
— This is a parallelogram.

Quadrilateral B (rectangle-like shape):
— Opposite sides are equal.
— All four angles are right angles (90 degrees).
— Opposite angles are equal (all are 90 degrees, so all angles are equal).
— This is a rectangle — a special parallelogram with all right angles.

Answer: Both A and B have opposite sides equal — they are parallelograms. In A, opposite angles are equal but not right angles. In B, all four angles are right angles (90 degrees) — B is a rectangle.

Q6 In the grid given below, draw two different kites and two different parallelograms.

SOLUTION

This is a drawing activity on the grid.

How to draw a kite on a grid:
Mark 4 points so that one diagonal is the line of symmetry. Two adjacent sides must equal another two adjacent sides. Example: mark a top point, then two side points at equal distances from the top, then a bottom point on the same vertical line as the top.

How to draw a parallelogram on a grid:
Mark a bottom-left point. Move right 4 squares to get the bottom-right point. Move up 2 squares and left 2 squares from the top-right to get the top-right corner. Move the same offset from bottom-left to get the top-left corner. Join all four points.

Draw two different sized kites and two different shaped parallelograms (one can be a rectangle).

Answer: Draw on the grid: (1) Two kites — each with two pairs of adjacent equal sides and one line of symmetry. (2) Two parallelograms — each with two pairs of opposite equal sides. One can be a rectangle (right angles) and one a slanted parallelogram.

Q7 Now use 3 triangles from the rhombus to form shapes. How many sides do each one have? Using 3 triangular pieces, try creating: (a) a 3-sided shape, (b) a 4-sided shape, and (c) a 5-sided shape.

SOLUTION

(a) 3-sided shape (triangle): Join all 3 triangles so that the outer boundary has only 3 corners. Place two triangles to form a larger triangle, then attach the third along one edge so the result is still triangle-shaped.

(b) 4-sided shape (quadrilateral): Arrange 3 triangles so the outer boundary has 4 corners. For example, place two triangles to form a parallelogram, then attach the third to one side.

(c) 5-sided shape (pentagon): Arrange 3 triangles so the outer boundary has 5 corners. Place two triangles to form a larger triangle, then attach the third to a slanted side so one edge sticks out and creates 2 extra corners.

There can be more than one way to make each shape.

Answer: (a) Arrange 3 triangles to form a triangle (3 sides). (b) Arrange them to form a quadrilateral (4 sides). (c) Arrange them to form a pentagon (5 sides). Multiple arrangements are possible for each.

Q8 Which of these shapes can be made with all 4 triangular pieces from the rhombus? Try and find out.
(a) Square (b) Rectangle (c) Triangle (d) Pentagon (5-sided) (e) Hexagon (6-sided) (f) Octagon (8-sided)

SOLUTION

Using all 4 triangular pieces from the rhombus (which together make the original rhombus when assembled):

(a) Square — No. The 4 triangles from a rhombus have unequal sides, so they tile into a rhombus shape, not a square.
(b) Rectangle — Yes. Arrange the 4 triangles in two pairs placed symmetrically to form a rectangle.
(c) Triangle — No. Four pieces cannot be arranged into a perfect triangle.
(d) Pentagon (5-sided) — No. A 5-sided shape cannot be formed with these 4 pieces.
(e) Hexagon (6-sided) — Yes. Arrange the 4 triangles with their longer sides facing outward to get a 6-cornered shape.
(f) Octagon (8-sided) — No. An 8-sided shape is not possible with only 4 triangles.

Try each arrangement by hand.

Answer: You can make: a Rectangle (b) and Hexagon (e) with all 4 pieces. Square (a), Triangle (c), Pentagon (d), and Octagon (f) cannot be made with these 4 rhombus triangles.

Exercise 7.5 — Try This — Equilateral and Scalene Triangles (p. 97)

Q1 Cut the equilateral triangle provided at the end of the book. Check if all the angles of an equilateral triangle are equal (by folding, as you did with the isosceles triangle). Then cut the equilateral triangle in half. How many sides of each new triangle are equal? What are scalene triangles?

SOLUTION

Checking angles of an equilateral triangle:
Fold the equilateral triangle so that two vertices meet. The fold line should pass through the third vertex. If the two halves match perfectly, the two base angles are equal. Repeat for another pair — all three angles are equal.
Result: Equilateral triangles have 3 equal angles.

Cutting the equilateral triangle in half:
When you cut an equilateral triangle in half (along the height from one vertex to the midpoint of the opposite side), you get two smaller triangles.
Each new triangle has: one short side (half the base), one medium side (the height), and one long side (a full side of the original equilateral triangle).
All three sides are different lengths — no two sides are equal.

Triangles with no equal sides are called scalene triangles.
In a scalene triangle, no two angles are equal either.

Answer: All three angles of an equilateral triangle are equal. When cut in half, each new triangle has 3 sides of different lengths — it is a scalene triangle. Scalene triangles have no equal sides and no equal angles.

Exercise 7.6 — Tangram — Shapes and Angles (p. 99)

Q1 Look at the tangram set given at the end of your textbook. Cut out all the shapes and name them.
(a) How are they same or different from each other?
(b) What do you notice about the angles of each of the shapes?
(c) What do you notice about the sides of each of the shapes?

SOLUTION

A tangram set has 7 pieces:
5 right-angled triangles (2 large, 1 medium, 2 small), 1 square, and 1 parallelogram.

(a) Same or different:
Same: all pieces fit together to make a larger square; all have straight sides.
Different: they vary in size and shape — some are triangles, one is a square, one is a parallelogram.

(b) Angles:
All the triangles are right-angled triangles — each has one 90-degree angle and two 45-degree angles.
The square has four 90-degree angles.
The parallelogram has two sharp angles and two wide angles (no right angles).

(c) Sides:
The 2 large triangles have the longest sides.
The medium triangle is smaller.
The 2 small triangles are the smallest.
The sides of all the shapes are related — they are multiples or fractions of the same base unit, which is why they fit together perfectly.

Answer: (a) All 7 pieces fit together into a square; they differ in size and shape (triangles, square, parallelogram). (b) All triangles have angles of 45-45-90 degrees; the square has all 90-degree angles. (c) All side lengths are multiples of the same unit, so the pieces fit together perfectly.

Q2 Use some or all of the pieces of your tangram set to make the following shapes (shown in the book): a large triangle, a small triangle, a rectangle, and a trapezium. There may be more than one way to do it.

SOLUTION

This is a hands-on puzzle activity. Use any combination of the 7 tangram pieces.

Model hints:
Large triangle: use the 2 large triangles placed hypotenuse-to-hypotenuse.
Small triangle: use the 2 small triangles placed hypotenuse-to-hypotenuse.
Rectangle: use the 2 large triangles placed so that their hypotenuses form the long sides, or combine a square with 2 triangles.

Trapezium: use 3 or 4 pieces arranged so one pair of opposite sides is parallel.

There is usually more than one way to fill each outline.

Answer: Use the tangram pieces to fill each outline. Hint: large triangle = 2 large triangles; small triangle = 2 small triangles; rectangle = 2 large triangles; trapezium = 3-4 pieces. There may be more than one solution.

Exercise 7.7 — Which Shape Am I? — Matching Statements to Shapes (p. 100)

Q1 Match each statement with the correct shape(s) from: Square, Rectangle, Rhombus, Parallelogram. Some statements may describe more than one shape.

1. All my angles are right angles, but all my sides are not equal.
2. All my sides are equal, but all my angles are not.
3. My opposite angles are equal, but my sides do not make a right angle.
4. Two pairs of sides are equal, but they do not make a right angle.
5. All my sides make right angles with each other and are equal.
6. My opposite angles are equal and so are my sides.
7. My opposite angles are equal and my sides make right angles.

SOLUTION

1. All angles are right angles, but sides NOT all equal => Rectangle
   (A rectangle has four 90-degree angles, but two different side lengths.)
2. All sides equal, but angles NOT all equal => Rhombus
   (A rhombus has 4 equal sides but opposite angles that are equal in pairs, not all the same.)
3. Opposite angles equal, sides do NOT make a right angle => Rhombus or Parallelogram
   (Both have opposite angles equal but no right angles in general.)
4. Two pairs of sides equal, but no right angle => Parallelogram or Kite
   (A parallelogram has two pairs of opposite equal sides; a kite has two pairs of adjacent equal sides — both without right angles.)
5. All sides equal AND all right angles => Square
   (A square is the only shape with 4 equal sides and 4 right angles.)
6. Opposite angles equal AND opposite sides equal => Parallelogram
   (This is the basic definition of a parallelogram. Square, rectangle, and rhombus are all special parallelograms.)
7. Opposite angles equal AND sides make right angles => Rectangle (or Square)
   (A rectangle has equal opposite angles — all 90 degrees — and right angles.)

Answer: 1 => Rectangle. 2 => Rhombus. 3 => Rhombus or Parallelogram (both fit). 4 => Parallelogram or Kite. 5 => Square. 6 => Parallelogram (and its special cases). 7 => Rectangle (or Square).

Exercise 7.8 — Kites — Paper Folding Activity (p. 100)

Q1 Make your own kite shape from a square piece of paper by following the steps:
(a) Start with a square piece of paper.
(b) Fold it towards the opposite corner along the diagonal (crease along diagonal).
(c) Open and fold corner A inwards, aligning the edge with the crease.
(d) Repeat on the other side, folding corner B inwards to align with the crease.
You have a kite shape! What shapes do you see in the kite?

SOLUTION

Follow the 4 folding steps to make the kite shape.

Shapes you can see in the finished kite:
— Triangles: the folded flaps on either side are triangles.
— The overall outline is a quadrilateral (4-sided shape) — the kite itself.

Properties of the kite you have made:
Two sides on the top (from the top point) are equal.
Two sides on the bottom (from the bottom point) are equal.
These equal sides are adjacent (they share a corner), making it a true kite shape.

Answer: Follow the folding steps to make the kite. You can see triangles inside the kite shape. The kite has two pairs of adjacent equal sides — the top two sides are equal and the bottom two sides are equal.

Exercise 7.9 — Play with Circles — Diameter and Quadrilateral (p. 101)

Q1 Draw a circle with a compass and mark its centre. Draw a diameter and mark both endpoints. Draw another diameter and mark its endpoints. Now join the four endpoints. What shape is formed? Check the sides and angles of the quadrilateral. Try with a different pair of diameters. What do you notice about the shape that is formed? Is it possible to create a 4-sided shape other than a rectangle through this process?

SOLUTION

When you join the four endpoints of two diameters of a circle, you get a quadrilateral.

What shape is it?
The shape is always a rectangle.

Why?
Both diameters pass through the centre and are equal in length (both equal the diameter of the circle).
When you join the four endpoints, the diagonals of the quadrilateral are both diameters — they are equal in length and they bisect each other at the centre.
A quadrilateral whose diagonals are equal and bisect each other is a rectangle.

No matter which two diameters you choose, the four endpoints always form a rectangle.

Can you get a shape other than a rectangle? No.
Any two diameters always create four points on the circle that form a rectangle, because the diagonals (the diameters) are always equal and cross at the centre.

Answer: The four endpoints of any two diameters always form a rectangle. The diagonals of this rectangle are the two diameters — equal in length and crossing at the centre. You cannot get any other 4-sided shape through this process.

Exercise 7.10 — Circle Designs — Thread Design on 24-Point Circle (p. 101)

Q1 Look at the circle marked with points 1 to 24. Join points 1 to 11, 11 to 2, 2 to 12, and so on till you reach back at 1. (Try it with different coloured threads on a thick paper or cloth.) Can you think of a way to make a design exactly like the image given (a flower pattern made of overlapping circles)?

SOLUTION

Circle design with threads:

Follow the joining rule — from each point, skip 10 points and connect. Continue until you return to the start.

Join: 1-11, 11-2, 2-12, 12-3, 3-13, 13-4, 4-14, 14-5, 5-15, 15-6, 6-16, 16-7, 7-17, 17-8, 8-18, 18-9, 9-19, 19-10, 10-20, 20-11, 11-21, 21-12 ... and so on back to 1.

This creates a beautiful star or spiral pattern inside the circle.

Using different coloured threads for each step makes the design more vivid.

Flower pattern (overlapping circles design):

To make the flower pattern shown, draw a circle. Keep the compass at the same radius.

Place the compass point on the circle itself and draw another circle of the same radius.

Place the compass at each new intersection point on the first circle and draw more circles of the same radius.

Continue until you have 6 circles arranged around the centre.

This creates the overlapping petal pattern.

Answer: Follow the 1-to-11, 11-to-2, 2-to-12, ... rule to create the thread design. For the flower pattern: draw 6 circles of the same radius, each centred on a point of the previous circle's boundary, to make overlapping petals.

Exercise 7.11 — Cube Connections — Cube Views, Removed Cubes, Painted Faces (p. 102)

Q1 Here are three views of a cube (top view, front view, and side view — each face has a different design). Can you draw them on the net in the correct order?

SOLUTION

This is a spatial reasoning activity with a cube net.
A cube has 6 faces. The net shown is a cross-shaped arrangement of 6 squares.

From the three views given (each showing a different face of the cube), identify:
— Which face is the top face
— Which face is the front face
— Which face is the right-side face

Then place each design in the correct square of the net so that when folded, the designs appear on the right faces.

Tip: The face opposite the top face in a cross net is usually two rows below it. The front face is directly below the top face. Use the three visible views as your guide and fill in the remaining 3 unseen faces.

Answer: Place each of the three given face designs on the correct square of the net. The top face folds down to become the top; the front face is below it; the side face is to the right. Fill the remaining squares by working out which faces are opposite each other.

Q2 Here are some big solid cube frames. How many small cubes have been removed from each cube? (Three cubes are shown — each has a square tunnel drilled straight through from each of its three pairs of faces: (a) a 3x3x3 cube with a 1x1 tunnel, (b) a 4x4x4 cube with a 2x2 tunnel, (c) a 5x5x5 cube with a 3x3 tunnel.)

SOLUTION

In each cube, a square hole is drilled straight through from all three directions (left-right, front-back, top-bottom). We add the cubes in the three tunnels, then take away the cubes that are counted more than once where the tunnels cross.

(a) 3x3x3 cube, 1x1 tunnel through all three directions:
Each tunnel removes a line of 3 cubes. Three tunnels = 3 + 3 + 3 = 9.
The single centre cube is shared by all three tunnels (counted 3 times), so subtract 2.
Removed = 9 - 2 = 7 small cubes. (20 cubes are left.)

(b) 4x4x4 cube, 2x2 tunnel through all three directions:
Each tunnel is 2 x 2 x 4 = 16 cubes. Three tunnels = 16 x 3 = 48.
Where two tunnels cross they share a 2 x 2 x 2 = 8 block; there are 3 such crossings, so subtract 8 x 3 = 24.
All three tunnels share the middle 2 x 2 x 2 = 8 block, which we subtracted one time too many, so add 8 back.
Removed = 48 - 24 + 8 = 32 small cubes. (32 cubes are left.)

(c) 5x5x5 cube, 3x3 tunnel through all three directions:
Each tunnel is 3 x 3 x 5 = 45 cubes. Three tunnels = 45 x 3 = 135.
Each pair of tunnels shares a 3 x 3 x 3 = 27 block; 3 pairs, so subtract 27 x 3 = 81.
All three share the middle 3 x 3 x 3 = 27 block, so add 27 back.
Removed = 135 - 81 + 27 = 81 small cubes. (44 cubes are left.)

Answer: (a) 7 small cubes removed (3x3x3 cube, 1x1 tunnel, 9 - 2 = 7). (b) 32 small cubes removed (4x4x4 cube, 2x2 tunnel, 48 - 24 + 8 = 32). (c) 81 small cubes removed (5x5x5 cube, 3x3 tunnel, 135 - 81 + 27 = 81).

Q3 Nisha has glued 27 small cubes together to make a large solid cube. She paints the large cube red. How many of the original small cubes have —
(a) three faces painted red?
(b) two faces painted red?
(c) one face painted red?
(d) no faces painted red?

SOLUTION

The large cube is 3x3x3 = 27 small cubes.
Only the outer surface is painted. The position of each small cube determines how many of its faces are painted.

(a) Three faces painted — corner cubes:
These sit at the 8 corners of the large cube. Each corner cube has 3 faces on the outside.
Count = 8 cubes.

(b) Two faces painted — edge cubes (not corners):
Each edge of the large cube has 3 small cubes, but we exclude the 2 corner cubes.
That leaves 1 middle cube per edge. A cube has 12 edges.
Count = 12 x 1 = 12 cubes.

(c) One face painted — face-centre cubes:
Each face of the large cube has a 3x3 arrangement. The 4 corner cubes and 4 edge cubes of each face are already counted above. The centre cube of each face has only 1 face painted.
A cube has 6 faces, so count = 6 x 1 = 6 cubes.

(d) No faces painted — the interior cube:
The very centre cube of the 3x3x3 is completely hidden.
Count = 1 cube.

Check: 8 + 12 + 6 + 1 = 27 ✓

Answer: (a) 8 cubes (corners — 3 faces painted). (b) 12 cubes (edge middles — 2 faces painted). (c) 6 cubes (face centres — 1 face painted). (d) 1 cube (interior — no faces painted). Total: 8+12+6+1 = 27.

Exercise 7.12 — Puzzle — Tanu's Shapes in a Line (p. 102)

Q1 Tanu arranged 7 shapes in a line: 2 squares, 2 triangles, 1 circle, 1 hexagon, and 1 rectangle. Find her arrangement using these clues:
(a) The square is between the circle and the rectangle.
(b) The rectangle is between the square and the triangle.
(c) The two triangles are next to the square.
(d) The hexagon is to the right of the triangle.
(e) The circle is to the left of the square.

SOLUTION

Let us work through the clues step by step.

From clue (e): Circle is to the left of a Square.
From clue (a): A Square is between the Circle and the Rectangle => Circle - Square - Rectangle.
From clue (b): Rectangle is between Square and Triangle => Square - Rectangle - Triangle.
So far: Circle - Square - Rectangle - Triangle.

From clue (c): The two Triangles are next to the Square.
We have two squares. The second square must have a triangle on each side.
Arrange: Triangle - Square - Triangle fits clue (c).

From clue (d): Hexagon is to the right of a Triangle.

Putting it together:
Position 1: Circle
Position 2: Square (first square)
Position 3: Rectangle
Position 4: Triangle (first triangle)
Position 5: Square (second square, with triangles on both sides)
Position 6: Triangle (second triangle)
Position 7: Hexagon (to the right of the second triangle)

Check all clues:
(a) Square(2) is between Circle(1) and Rectangle(3) ✓
(b) Rectangle(3) is between Square(2) and Triangle(4) ✓
(c) Two triangles at positions 4 and 6 are both next to Square(5) ✓
(d) Hexagon(7) is to the right of Triangle(6) ✓
(e) Circle(1) is to the left of Square(2) ✓

Answer: The arrangement is: Circle — Square — Rectangle — Triangle — Square — Triangle — Hexagon.

Exercise 7.13 — Icosahedron and Dodecahedron — 3-D Shapes (p. 103)

Q1 Use the nets provided at the end of the book to make icosahedron and dodecahedron models. Then answer:
— What shapes do you see in an icosahedron and a dodecahedron?
— Do all the faces look the same?
— How many faces meet at a vertex?
— Do the same number of faces meet at each vertex?
— How many edges do you see?

SOLUTION

Icosahedron:
Shapes on faces: equilateral triangles.
Do all faces look the same? Yes — all 20 faces are equilateral triangles.
Faces at each vertex: 5 triangles meet at every vertex.
Same number at each vertex? Yes.
Number of edges: 30 edges.

Dodecahedron:
Shapes on faces: regular pentagons (5-sided shapes).
Do all faces look the same? Yes — all 12 faces are regular pentagons.
Faces at each vertex: 3 pentagons meet at every vertex.
Same number at each vertex? Yes.
Number of edges: 30 edges.

How to count edges without missing any or double-counting:
Count all edges of one face, then move to adjacent faces and count only the NEW edges (not the shared one you already counted). Or: use the formula — Edges = (number of faces x sides per face) / 2, because each edge is shared by 2 faces.
Icosahedron: (20 x 3) / 2 = 30 edges.
Dodecahedron: (12 x 5) / 2 = 30 edges.

Other shapes with all faces the same (Platonic solids):
Tetrahedron (4 triangular faces), Cube (6 square faces), Octahedron (8 triangular faces).
In each, the same number of faces meets at every vertex.

Answer: Icosahedron: 20 equilateral triangle faces; 5 faces meet at each vertex; 30 edges. Dodecahedron: 12 regular pentagon faces; 3 faces meet at each vertex; 30 edges. All faces look the same in both. Edge count formula: (faces x sides per face) / 2.